



TRR – Goddard Flight Replica Ground Testing

TEST REQUIREMENTS & HARDWARE STATUS

**SANDY ELAM
TD61**

3/12/03



TRR – Goddard Flight Replica Ground Testing

OBJECTIVE

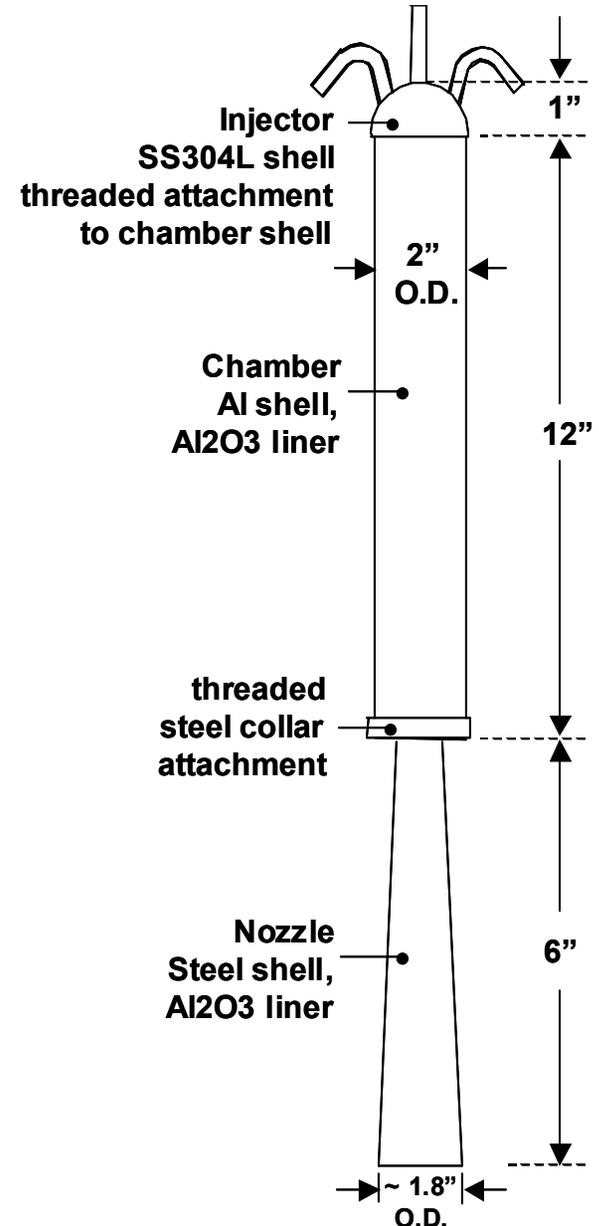
VERIFY THRUST LEVEL & OPERATING CONDITIONS
FOR THE FLIGHT REPLICA TCA DESIGN

HARDWARE SUMMARY

- **NOZZLE**
 - Steel shell, alumina liner (insulating fabric filler)
 - Steel retaining ring welded to aft end
 - Steel collar welded to forward end
- **CHAMBER**
 - Al shell, alumina liner (insulating fabric filler)
 - Shell O.D. threaded at forward and aft end
- **INJECTOR**
 - SS304L shell, zirconia coated using VPS
 - Threaded I.D. edge

TEST CONDITIONS

- Propellants: GOX, gasoline
- $P_c \sim 50$ psig, MR ~ 2.4
- Thrust ~ 10 -25 lb_f





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HARDWARE DETAILS - INJECTOR

- 2 - 3/8" tubes for GOX, gasoline inlets
- Injector shell includes
 - 1 - 3/8" dia hole for GOX flow
 - 4 - 0.040" dia holes for gasoline flow
- Supply line orifices control flow rates
- Zirconia coating provides thermal protection
- 2 Designs provided for testing:

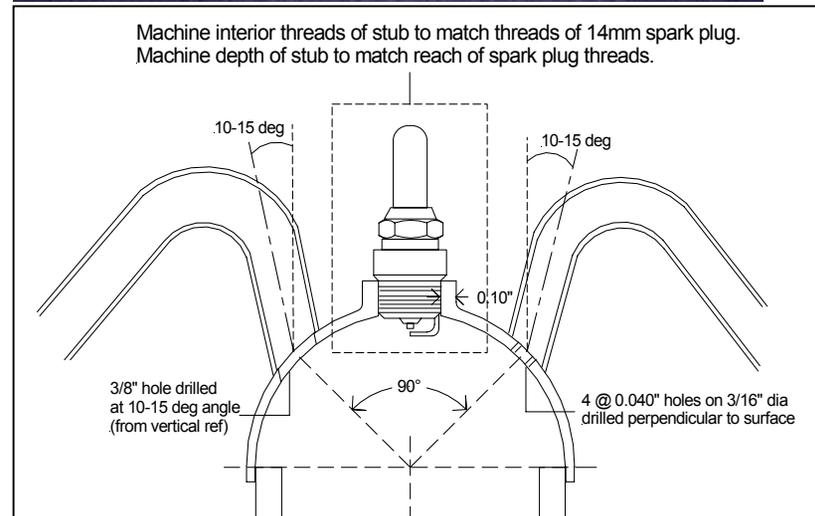
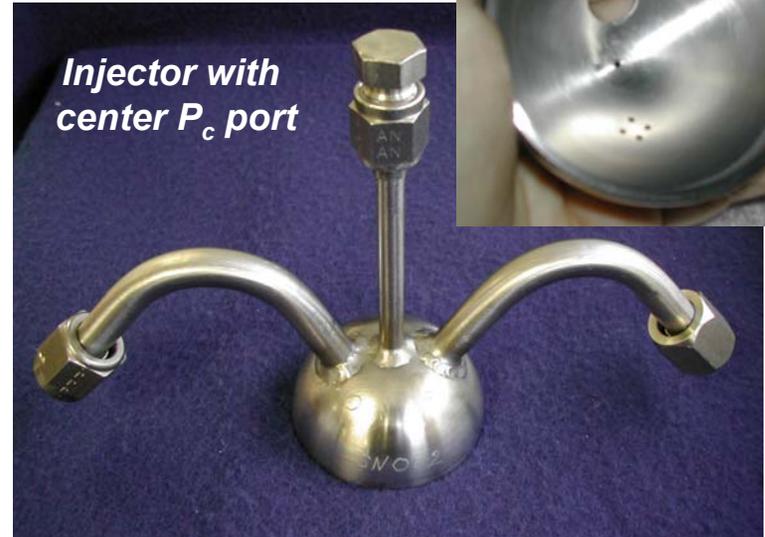
1) 1/4" welded center tube for P_c port

- 1/16" dia hole machined into shell
- Compare P_c with supply line pressures
- Spark igniter fed thru nozzle aft end

2) Machined "Stub" for spark plug igniter

- Eliminates igniter thru chamber throat
- No P_c measurement required

Injector "holes"



Spark Plug Igniter with Machined Stub



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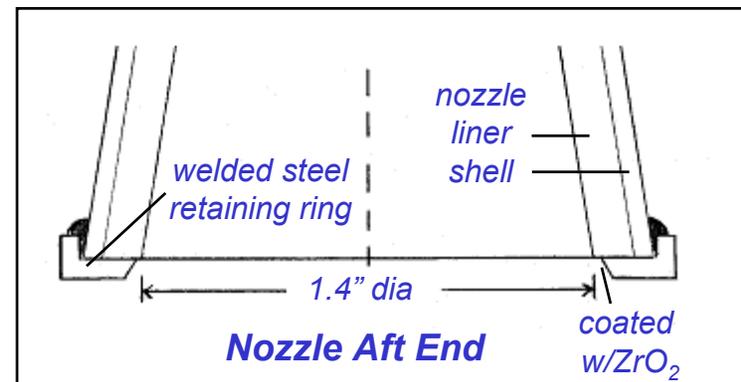
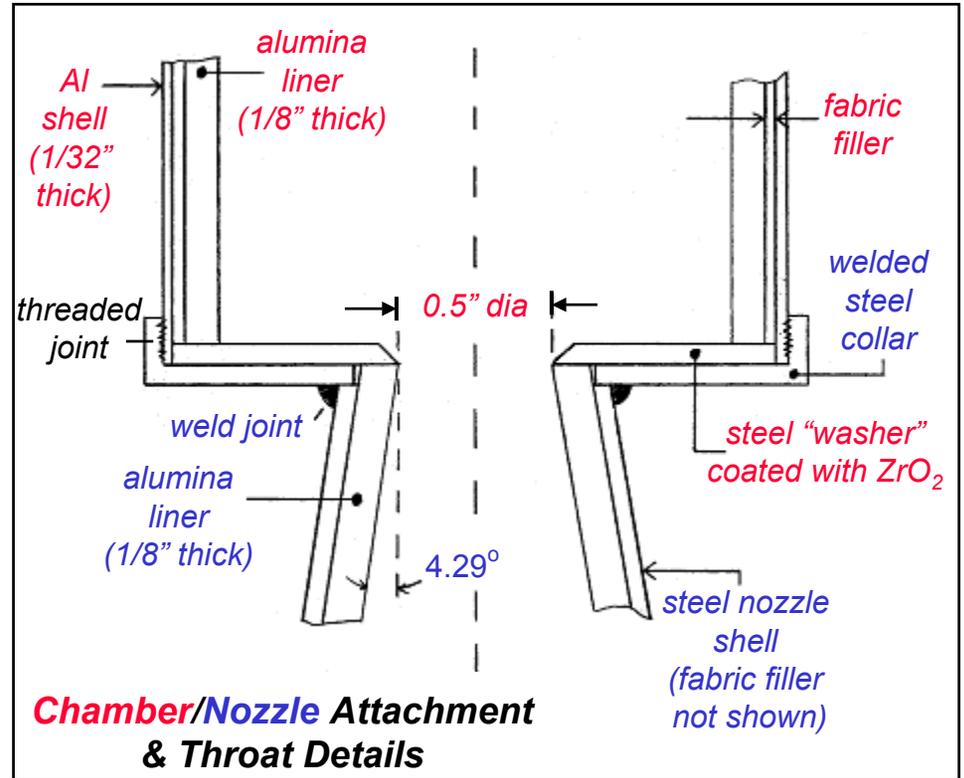
HARDWARE DETAILS – CHAMBER/NOZZLE

Chamber

- 2 sizes available
 - 1) I.D. = 1.625", O.D. = 1.875"
 - 2) I.D. = 1.5", O.D. = 1.75"
- 5 of each size purchased from International Ceramics Engineering
- Steel “washer” creates “throat”
 - coated with zirconia for thermal protection

Nozzle

- Initial length = 6"
- Alternate length = 5"
(depending on thrust results)
- 5 liners purchased from International Ceramics Engineering





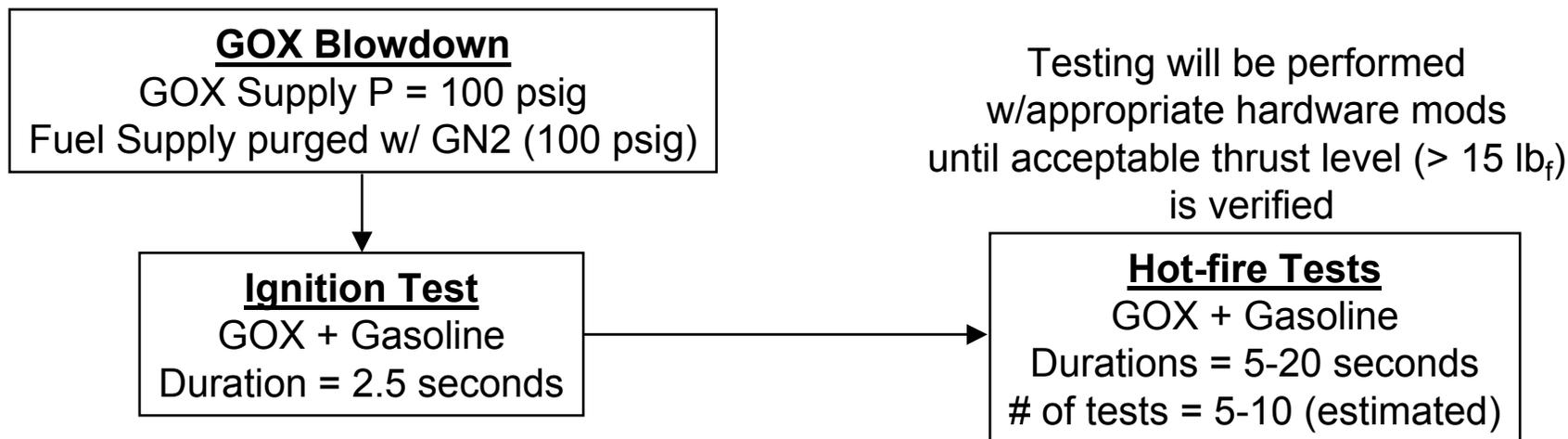
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TEST CONDITIONS

	Supply Pressure (psig)	Flow Control Orifice diameter (in)	flow rate (lb _m /s)
GOX System	100	0.21	0.06
	Purged w ith GN2 supplied at 100 psig (& controlled by 0.070" orifice in purge line)		
Fuel System	100	0.042	0.025
	Purged w ith GN2 supplied at 100 psig (& controlled by 0.0145" orifice in purge line)		

Ambient Propellants: GOX, 87 Octane Gasoline (additives will be considered, as necessary)
Expected Conditions: P_c ~ 50 psig, MR ~ 2.4

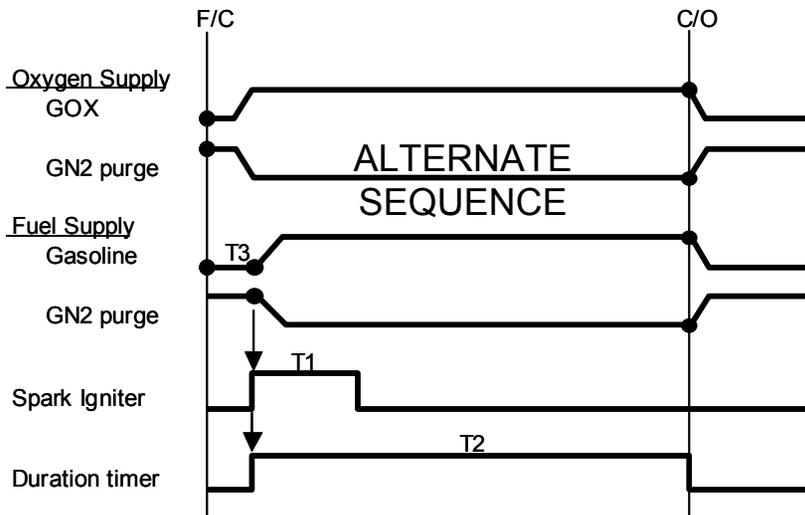
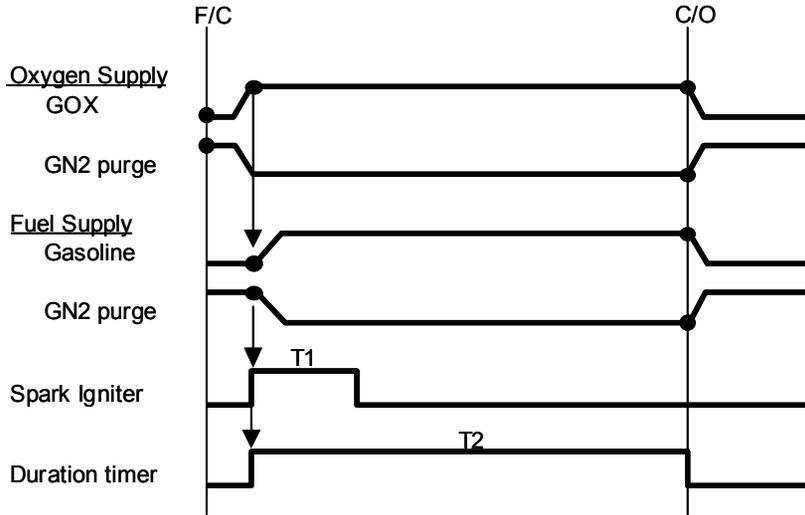
TEST PLAN





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CONTROL SEQUENCE



TEST REQUEST

GODDARD FLIGHT REPLICA GROUND TESTING TEST REQUEST

Test #: BD-1 Date Requested: 3/14/03
 Test Request Revision: 1 Date Conducted:

Sandy Elam
 MSFC TEST REQUESTER

Paul Dumbacher
 MSFC TEST ENGINEER

Changes Since Last Test: n/a

Special Instructions: none

Revision Summary: original, provided 3/5/03

Test Conditions

Objectives: GOX Blowdown
 $P_c < 50$ psig

MR= n/a

Hardware: Injector S/N 003, chamber alumina liner S/N 001 (I.D. = 1.625"), chamber aluminum shell S/N 001, steel nozzle (3/16" thick, no separate liner)

Propellant Supply:

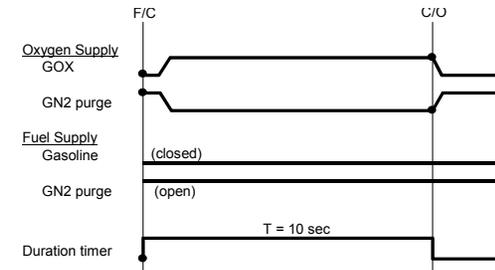
System	Fluid	Temp (F)	Pressure (psig)	Orifice Dia (in)	Flow rate (#/s)
Oxidizer	GOX	ambient	100 (P4305)	0.21	0.06
Fuel	n/a	n/a	n/a	0.042	n/a

Purge Supply:

System	Fluid	Temp (F)	Pressure (psig)	Orifice (in)
Oxidizer	GN2	ambient	100 (P4261)	0.070 dia
Fuel	GN2	ambient	100 (P4401)	0.0145 dia

Sequence:

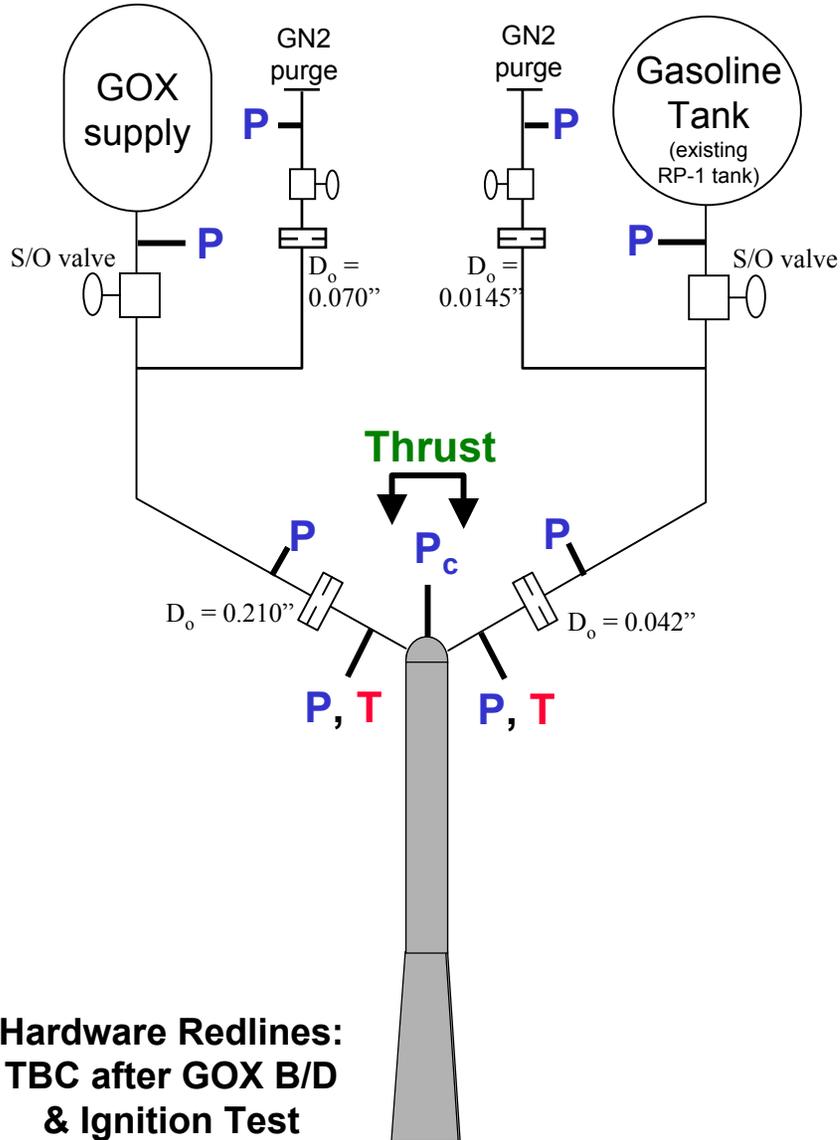
No specific valve ramp rates required





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INSTRUMENTATION & DATA REQUIREMENTS



Hardware Redlines:
TBC after GOX B/D
& Ignition Test

Fuel Supply:

- Gasoline supply pressure (0-150 psig)
- Orifice upstream pressure (0-150 psig)
- Orifice downstream pressure (0-100 psig)
- Orifice downstream temp (ambient-6000 F)

GOX Supply:

- GOX supply pressure (0-150 psig)
- Orifice upstream pressure (0-150 psig)
- Orifice downstream pressure (0-100 psig)
- Orifice downstream temp (ambient-6000 F)

Additional instrumentation:

- Chamber pressure (0-100 psig)
- Thrust (0-30 lb_f)
- Purge supply pressures (0-150 psig)

Other:

- No high frequency data required
- No high speed film required
- Standard video & photo services requested



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HARDWARE STATUS

- **Injector**
 - Initial unit (S/N 003) completed, uncoated
 - Additional units machined (VPS scheduled for 3/14/03)
- **Chamber**
 - Liner received, shell machined
 - Fabric filler available
 - Throat washer machined (VPS scheduled for 3/14/03)
- **Nozzle**
 - Ceramic liners expected 3/19/03
 - SS304L “nozzle” will support GOX B/D
& “ignition” testing until ceramic liners arrive
 - Collar & retaining ring machined (VPS scheduled for 3/14/03)
- Appropriate ass’y will be available for GOX B/D & Ignition testing
- 1st assembly available for duration hot-fire testing: 3/21/03



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TEST FACILITY

**Paul Dumbacher
TD71**

3/12/03



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Facility Description:

- GOX / Hydrocarbon fuel
- Dual hydrocarbon fuel systems
- Start-up and mainstage flowpaths for up to 100 lbs thrust
- Thrust Measurement

Facility Preparations:

- Removed Laser Ignition combustion chamber
- Added firex leg to protect laser ignition connex
- Removed the “dog house” canopy

Test Rig Preparations :

- Removed Laser Ignition combustion chamber
- Modified GOX purge and fuel purge flow rate orifices
- Modified GOX and fuel supply tubing for new injector interfaces
- Replaced load-cell (new range and cal)

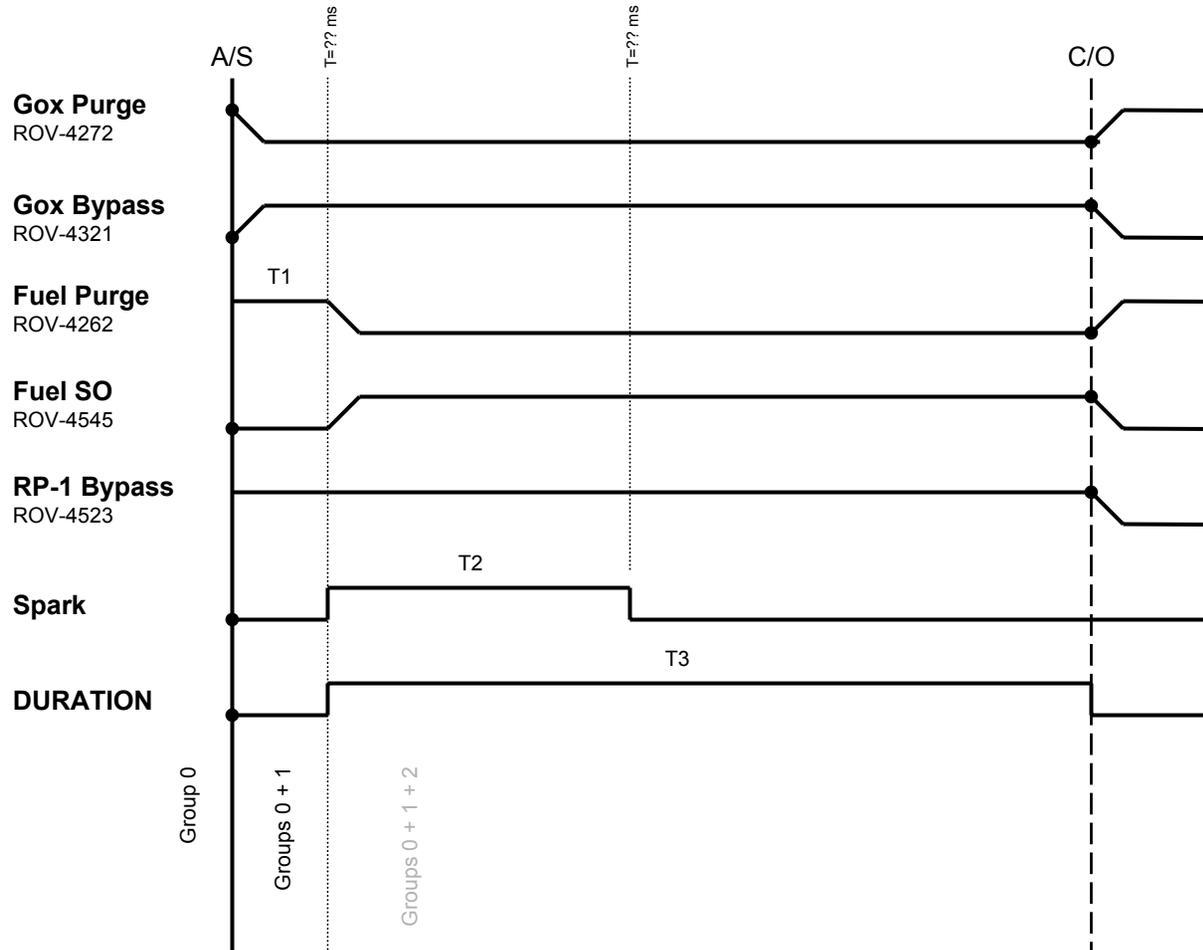




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P2354 Goddard Replica Sequence

Sequence p2354001 – 03Mar11





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INSTRUMENTATION

Jason Elmore

TD72

3/12/03



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Instrumentation Preparations:

- Replaced Load Cell
- Wrapped exposed leads with heat tape

03-12-2003

MID	CH#	MID DESCRIPTION	RANGE	UNITS
42P1	58	Optical Port Purge Press	500	PSIS
42T1	57	Optical Port Purge Temp	100	DEGF
FM4115	1	Cooling Water Flow	30	GPM
LC4601	4	Measured Thrust A	100	LBS
LC4602	5	Measured Thrust B	100	LBS
P355	15	GOX Trailer Press	3000	PSIG
P4102	6	Cooling Water Supply Press	1000	PSIG
P4115	7	Cooling Water Outlet Press	1000	PSIG
P4205	8	ROV Control Pressure	200	PSIG
P4215	9	RP-1 Tank Supply Pressure	1000	PSIG
P4225	10	AF Tank Supply Press	1000	PSIG
P4261	11	Fuel/GOX Purge Press	3000	PSIS
P4265	12	Fuel Trickle Purge Pressure	1000	PSIG
P4275	14	GOX Trickle Purge Pressure	1000	PSIG
P4305	37	GOX Press	1000	PSIS
P4322	18	GOX Bypass Venturi Inlet Press	1000	PSIG
P4324	19	GOX Bypass Venturi Outlet Press	1000	PSIS
P4332	20	GOX Main Venturi Inlet Press	1000	PSIS
P4334	21	GOX Main Venturi Outlet Press	1000	PSIG
P4399	22	Injector GOX Press	1000	PSIG
P4401	23	Fuel Purge Set Pressure	1000	PSIG
P4402	24	AF Tank Bottom Press	1000	PSIG
P4421	25	AF Venturi Inlet Press	1000	PSIS
P4422	27	Fuel Purge Orifice Inlet Pressure	1000	PSIS
P4501	56	RP-1 Tank Top Press	1000	PSIS
P4502	38	RP-1 Tank Bottom Press	1000	PSIG
P4521	29	RP-1 Bypass Line Pressure	1000	PSIG
P4522	30	RP-1 Venturi Inlet Pressure	1000	PSIG
P4531	31	RP-1 Main Venturi Inlet Press	1000	PSIG
P4532	32	RP-1 Main Venturi Outlet Press	1000	PSIS
P4599	33	Injector Fuel Press	1000	PSIG
P4601	34	Chamber Press	300	PSIS
T4102	35	Cooling Water Supply Temp	0-200	DEGF
T4115	36	Cooling Water Outlet Temp	0-400	DEGF
T4322	49	GOX Bypass Venturi Inlet Temp	40 - 150	DEGF
T4324	50	GOX Bypass Venturi Outlet Temp	40 - 150	DEGF
T4332	51	GOX Main Venturi Inlet Temp	40 - 150	DEGF
T4334	52	GOX Main Venturi Outlet Temp	40 - 150	DEGF
T4399	53	Injector GOX Temp	40 - 150	DEGF
T4402	46	AF Tank Bottom Temp	40 - 150	DEGF
T4421	47	AF Venturi Inlet Temp	40 - 150	DEGF
T4422	48	AF Venturi Outlet Temp	40 - 150	DEGF
T4502	41	RP-1 Tank Bottom Temp	40 - 150	DEGF
T4521	42	RP-1 Bypass Line Temp	40 - 150	DEGF
T4522	43	RP-1 Venturi Inlet Temp	40 - 150	DEGF
T4531	44	RP-1 Main Venturi Inlet Temp	40 - 150	DEGF
T4532	45	RP-1 Main Venturi Outlet Temp	40 - 150	DEGF
T4599	54	Injector Fuel Temp	40 - 150	DEGF
T4600	55	Ambient Temp	32 - 150	DEGF



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TEST CONTROL

**Be Trieu
TD73
3/12/03**



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Control System Preparations:

- Bypass logic for laser control interfaces
- Activate logic for spark wire
- Activate redline cuts as required after GOX blowdown
- Firex switch modification



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QUALITY

**Chris Shepherd
QS10**

3/12/03



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SAFETY

**Johnney Mason
HEI**

3/12/03



GODDARD ROCKET PROPELLANT TESTING Safety Analysis

Scope

- Assess Facility, Test Stand, and Test Operations for Safety Concerns, which could lead to Personnel Injury, Property Loss, and/or Equipment Damage.

Method

- Review All Test Requirements and the Assessments for Advanced Fuels and Laser Ignition Tests
- Inspection and Walk-Through of the facility
- Discussions with Test Personnel

Recommendations and Closures

- 3 Concerns Identified
- 3 Concerns - Closed

Continued S&MA support Activities

- Complete verification of controls for “open” items
- Final walk-through of the facility



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GODDARD ROCKET PROPELLANT TESTING Safety Analysis

No	CONCERN	CONTROL	STATUS
1	QD Requirements	A review of the use of gasoline with the Advanced Fuel test rig provided no requirement greater than the requirements used for the Laser Ignition Test work. Using the QD of 300 feet that was established for the Ignition testing will provide an adequate distance for the Goddard testing.	Closed
2	Fire to the foam on the CONX from a gasoline fire or test failure resulting in fire.	The FIREX system was setup and operationally checked out by TPS-HCF-1298-M on 3/07/03.	Closed
3	Personnel exposure to the gasoline causing injury or illness.	During all material handling where personnel are potentially exposed to gasoline, as a minimum the requirements found in the MSDS will be followed. These requirements are: Goggles with Face Shield; Chemical protective gloves (Nitrile Rubber) and splash aprons; and depending on time and available ventilation respiratory protection may be required.	Closed